GUIDELINES ON APPLYING FOR THE APPROVAL OF WATER AND SEWAGE WORKS TO DEAL WITH ZEBRA MUSSEL CONTROL

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Jim Bradley, Minister/ministre

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SUMMARY

SINCE ITS INTRODUCTION INTO LAKE ST. CLAIR IN 1986, THE ZEBRA MUSSEL HAS NOW SPREAD FROM LAKE ST. CLAIR THROUGH MOST OF LAKE ERIE AND ALSO INTO THE ST. LAWRENCE RIVER FROM KINGSTON TO CORNWALL. ITS BIOLOGICAL CHARACTERISTICS ALLOW IT TO SPAWN PROLIFICALLY AND SPREAD QUICKLY BY FLOATING LARVAL STAGES. THE MUSSEL'S ABILITY TO ATTACH AND GROW ON ANY SOLID SURFACE (I.E. ROCKS, PIERS, BOATS, BUOYS, FISHING NETS, INTAKE PIPES AND OTHER MUSSELS) AND FILTER FEED ON LARGE QUANTITIES OF PHYTOPLANKTON IS CREATING SERIOUS ECOLOGICAL, NAVIGATIONAL, COMMERCIAL, RECREATIONAL AND WATER TAKING PROBLEMS.

THE GREATEST IMPACT AT PRESENT IS ON WATER TAKING FACILITIES. THE COLONIZATION OF WATER INTAKE PIPES AND IN-PLANT DISTRIBUTION SYSTEMS BY ZEBRA MUSSELS HAS LED TO SEVERE CLOGGING OF PIPES AND LOSS OF WATER INTAKE CAPACITY RESULTING IN PLANT SHUTDOWNS AND SHORTAGES OF WATER SUPPLIES FOR DOMESTIC, INDUSTRIAL AND FIRE PROTECTION PURPOSES.

OF THE VARIOUS CONTROL METHODS (PHYSICAL, MECHANICAL, BIOLOGICAL, CHEMICAL) PROPOSED TO DATE, THE BEST AND MOST PRACTICAL, OVER THE SHORT-TERM, IS CHLORINATION (I.E. USE OF CHLORINE GAS AND/OR SODIUM HYPOCHLORITE). IN ORDER TO PREVENT NEW AND FURTHER INFESTATIONS OF WATER TREATMENT, POWER GENERATING AND INDUSTRIAL PLANTS, AND OTHER WATER TAKING WORKS, CONTROLLED APPLICATION OF CHLORINE IS ACCEPTABLE FOR TREATING THE TARGET ZEBRA MUSSEL LARVAE AS SOON AS THEY APPEAR IN LATE MAY OR EARLY JUNE BEFORE THEY HAVE AN OPPORTUNITY TO SETTLE AND COLONIZE.

THE ONTARIO GOVERNMENT HAS SET UP AN INTERMINISTERIAL COMMITTEE, WITH THE MINISTRY OF NATURAL RESOURCES DESIGNATED AS THE LEAD AGENCY. ONE OF THE FUNCTIONS OF THIS COMMITTEE IS TO PURSUE RESEARCH INITIATIVES TO DETERMINE THE MOST EFFECTIVE WAY OF CONTROLLING ZEBRA MUSSEL COLONIZATION OF WATER INTAKES AND PIPES.

THE "GUIDELINE" DOCUMENT DESCRIBES THE NATURE OF THE PROBLEM, CONTROL METHODS WITH EMPHASIS ON THE PREFERRED SHORT-TERM CONTROL OPTION, I.E. CHLORINE APPLICATION, AND "TYPICAL" SPECIAL TERMS AND CONDITIONS TO BE INCLUDED ON ALL APPLICATIONS AND PERMITS FOR WATER AND SEWAGE WORKS.

APPLICATIONS FOR "APPROVAL OF WORKS" MUST BE MADE UNDER THE ONTARIO WATER RESOURCES ACT FOR THE USE OF CHLORINE AGAINST ZEBRA MUSSELS AND FOR ALL ALTERATIONS NECESSARY TO ENABLE THIS USE. INITIATION OF SUCH A USE OR OF SUCH ALTERATIONS WITHOUT APPROVAL MAY BE IN CONTRAVENTION OF THE OWRA AND OTHER PROVINCIAL AND FEDERAL STATUTES.

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INTRODUCTION

The invasion of zebra mussels into the lower Great Lakes is creating a very serious and urgent problem for water treatment plants and industrial establishments which draw quantities of raw water from these lakes. Zebra mussel colonization of intake pipes and in-plant water cooling and distribution systems has already severely reduced intake water capacity leading to: power generating and industrial plant shutdowns; shortages of adequate water supplies for public and industry use; and potential safety hazards if cooling or fire protection systems fail due to lack of sufficient water.

1.0 NATURE OF THE PROBLEM

1.1 BACKGROUND

Zebra mussels are believed to have been introduced into the Great Lakes in 1986, as a result of the discharge of ballast water from ship(s) which had visited Europe.

Zebra mussels were first detected in 1988 in Lake St. Clair, and later in the Detroit River and the western basin of Lake Erie.

By the end of 1989, the mussel had spread upstream into the St. Clair River and downsteam through Lake Erie into the western basin of Lake Ontario.

They have also been found in Lakes Michigan, Huron and Superior, and St. Lawrence River from Kingston to Cornwall.

1.2 BIOLOGY

Adult zebra mussels, Dreissena polymorpha (Pallas 1771), are small (2.5 to 5 cm) bivalve molluscs with elongated shells marked by alternating light and dark bands.

Biological characteristics of this organism allow it to spawn prolifically and disperse over large distances by means of floating free swimming larval stages.

When the water temperature reaches 12°C, generally between June and October, adult females (two-year-old) produce eggs (up to 40,000 each).

Subject to fertilization, the eggs hatch in a few days into microscopic, free-swimming larvae called "veligers".

Within three weeks of hatching, the larvae start to develop a shell, become too heavy to float and start to "settle".

They attach to any solid surface [e.g. rocks, piers, boats, buoys, cars, fishing nets, pipes (internally and externally) and other mussels] by sticky threads.

Densities of 700,000 mussels/m^2 have been reported at the Monroe Power Plant in Michigan.

Lifespans in Europe average between 3.5 to 5 years.

Zebra mussels filter feed on phytoplankton (microscopic plants).

1.3 IMPACTS

1.3.1 Ecological

Removal of phytoplankton will reduce zooplankton populations which in turn may affect fish populations.

Extensive colonization of shoal areas will impair fish spawning areas.

Potential to eradicate native species of molluscs.

Potential to become vectors of harmful parasites in waterfowl, fish, wildlife and possibly humans.

1.3.2 Water Taking

Colonization of raw water intake pipes and in-plant distribution systems causes: loss of intake capacity; obstruction of valves; production of foul odours and taste to water from decaying flesh; noxious and dangerous methane gas production; and extensive pipe corrosion due to anaerobic conditions created by the zebra mussels.

1.3.3 Commercial/Recreational

Commercial navigation, fishing and recreational boating can be adversely affected.

Shells washed up unto nearby beaches create aesthetic, health and safety problems.

2.0 CONTROL METHODS

The most important control strategy for zebra mussel infestations of water treatment, power generation and industrial facilities is to prevent the entry and establishment of the mussel in such systems.

European and Soviet experiences indicate that it is best to eliminate zebra mussels at the free-floating, free-swimming "veliger" stage before the larvae have an opportunity to settle and colonize within the distribution system.

Once colonization occurs, the elimination and removal of adult mussels presents additional problems.

2.1 PHYSICAL/MECHANICAL

Various physical/mechanical methods have been proposed. These include:

- microscreens, strainers and filters to prevent entry;
- increased current flow rates to prevent settling and colonization (at velocities greater than 1.5 to 2.0 m/s the veliger larvae do not settle);
- physical scraping or "pigging" of intakes to remove established colonies;
- electrical currents to discourage attachment;
- ultrasonic vibrations for avoidance control;
- extending intake pipes into deeper waters not populated by mussels (where and if possible);
- infiltration bed/gallery systems to prevent entry and establishment;
- thermal shock to kill larvae and adults.

At present, the use of physical/mechanical methods for prevention of zebra mussel settling and colonization of intake water facilities is not practical due to the current design characteristics of some of the facilities; the experimental nature of some of the

techniques; or the limited period of time left to implement control programs.

Building additional intakes to allow for shutdown and cleaning; redesigning intakes to extend the pipe or increase flow rates; or constructing infiltration bed/gallery systems are the preferred methods of control over the long term but they may not be feasible for the short-term.

2.2 SHORT-TERM CONTROL METHOD

Currently in Ontario, the use of chlorine products (chlorine gas, sodium hypochlorite) is approved as a water treatment chemical for the prevention and control of zebra mussel infestations of water taking facilities.

This has proven to be an effective control option, based upon extensive European experience and preliminary North American investigations.

In addition to the use of chlorine, which is approved on an interim basis, other control measures must be evaluated before deciding on the short-term control method.

2.3 LONG TERM CONTROL METHODS

As part of ongoing research, the Ministry requires that long term control methods, other than chlorination (chlorine gas or sodium hypochlorite) be developed as quickly as possible.

3.0 CHLORINE APPLICATIONS/CONDITIONS OF USE

The use and handling of chlorine gas and/or sodium hypochlorite by trained staff must meet Provincial Safety and Design Guidelines with regard to receiving, storage and application.

Chemicals for intended use must be standard products used in the chlorination of potable water that comply with American Water Works Association Standards. Other suppliers may be considered on-site specific instances based on acceptability of the chemicals.

Design of facilities must incorporate safety requirements and contingency plans must be in place to minimize impact on surrounding areas.

Chlorination for zebra mussel control may be conducted at most of the water taking facilities located in areas infested by zebra mussels.

Chlorination to prevent colonization could also be conducted at facilities presently not infested with zebra mussels if adult zebra mussels are present in the vicinity of their intake and/or veliger larvae are detected in the intake water.

3.1 WATER TREATMENT PLANTS (CLOSED SYSTEMS)

Chlorine may be added to raw water intakes only during the breeding season (generally June to October) when water temperature reaches 12°C or when zebra mussel larvae are detected, but breeding activity may extend beyond this period and occur at slightly lower temperatures.

The point of chlorination must be located inside the mouth of the intake pipe to prevent chlorinated water from entering the lake.

A total chlorine residual of 0.5 to 1 mg/L is required to kill the larvae and prevent additional zebra mussel infestation in the intakes. This would generally result in a dosage requirement in the order of 1 to 5 mg/L chlorine (normal water treatment levels).

Chlorine must be added at the mouth of the intake pipe through a diffuser system which will inject chlorine only during the time when the low lift pumps are in operation.

Automatic chlorine residual analysers at low lift pumping stations must be used to monitor the amount of chlorine added to the inlet works so as to ensure optimum chlorine additions.

The chlorine added at the intake works may generally offset the amount of chlorine required elsewhere in the water treatment system.

A comprehensive sampling and monitoring program must be in place to monitor concentrations of Trihalomethanes (THMs). Concentrations of THMs must not exceed the maximum acceptable concentrations as set out in the Ontario Drinking Water Objectives.

To provide operational and water quality data, it will be necessary to provide readily available unchlorinated raw water samples.

3.2 POWER GENERATING STATIONS (FLOW-THROUGH SYSTEMS)

General

All Ontario Hydro fossil, nuclear and hydraulic stations on the Great Lakes may be equipped with systems which will allow them to inject chlorine into their service water systems (low pressure, high pressure, fire protection and emergency shutdown systems) on a continuous or intermittent basis.

(These systems generally represent only 10% of all cooling water flow.)

Specific

Chlorine may be added to raw water intakes only during the breeding season (generally June to October) when water temperature reaches 12°C or when zebra mussel larvae are detected, but breeding activity may extend beyond this period and occur at slightly lower temperatures.

The point of chlorination must be located inside the mouth of the intake pipe, preferably through a diffuser system.

Total residual chlorine in the discharge at the outfall channel prior to entering the lake cannot exceed 0.01 mg/L. An automatic total residual chlorine analyzer must be installed to continuously monitor the discharge at the outfall.

Where compounds are not being used for dechlorination, mixing the chlorinated surface water discharge with the unchlorinated cooling water discharge, may be used to ensure that the total chlorine residual in the outfall channel will be less than 0.01 mg/L.

Dechlorination, when total residual chlorine exceeds 0.01 mg/L, can be implemented, for example, by the use of sulphur dioxide and/or aqueous solutions of sulphite compounds. Other effective dechlorination methods are also acceptable.

A biological program must be established to monitor the impact of chlorination. Benthic organisms in the discharge plume (beyond the scouring area of the plume) must be analysed before the chlorine system is turned on and after the season is complete.

A sampling and monitoring program may be required to monitor concentrations of Trihalomethanes (THMs) in the discharge, during the chlorination period.

3.2.1 Intermittent Chlorination

Chlorine may be added for 30 minutes every twelve hours at a rate which will result in 2 mg/L of total residual chlorine at the point of injection.

3.2.2 Continuous Chlorination

Where intermittent chlorination cannot be used, continuous chlorination at 0.3 mg/L total residual chlorine at the point of injection may be used.

3.3 INDUSTRY AND OTHER WATER TAKING ESTABLISHMENTS (INCLUDING NO DIRECT DISCHARGE SYSTEMS)

The use of chlorine for control of zebra mussels at all industrial and other facilities will be permitted provided the following are met:

- Chlorine may be added to raw water only during the breeding season. This generally extends from June to October when water temperature reaches 12°C, but breeding activity may extend beyond this period and occur at slightly lower temperatures.

- Chlorine may be injected into intakes through a diffuser system only during the time when the intake pumps are operating.

- Chlorine dosage must be such as to provide effective control on zebra mussel infestation at intakes while minimizing the formation of chloro-organics.

- All direct discharges to a receiving water course must not exceed a total chlorine residual of 0.01 mg/L.

- Continuous monitoring of chlorine concentrations in the discharge to a receiving water course is required to ensure that the concentration does not exceed 0.01 mg/L total residual chlorine.

- Dechlorination, if required for immediate discharge or protection of subsequent treatment processes, can be implemented by the use of sulphur dioxide

and/or aqueous solutions of sulphite compounds. Other effective dechlorination methods are also acceptable.

- Biological monitoring of benthic invertebrate communities to assess environmental impacts may be required in the vicinity of the discharge location, immediately before and after the chlorination period.

- A sampling and monitoring program may be required to monitor concentrations of THMs in the discharge, during the chlorination period.

NOTE: At existing facilities, discharge limits should either be maintained or modified to comply with program needs.

4.0 SPECIAL TERMS AND CONDITIONS

General

Certificates of Approval for existing facilities have generally incorporated the following requirements:

- Definitions
- Legal obligations of the owner
- Entry and inspection
- Operation and maintenance
- Performance
- Monitoring and reporting

Supplementary requirements are defined below.

4.1 WORKS

Works means the facility described in the owner's application, in the certificate and in the supporting documentation referred to herein, to the extent defined in the certificate. (The chlorine injection pipe may be laid within the intake pipe or if outside the intake pipe, a pipe sleeve is necessary.)

4.2 OPERATION AND MAINTENANCE

The owner shall ensure that, at all times, the related equipment and appurtenances are properly operated and maintained.

4.3 PERFORMANCE

The owner shall design and construct the chlorination system in such a manner and with such facilities that the requirements set out in Subsections (a), (b) and (c) below shall be satisfied.

(a) **Water Treatment Plants (Closed Systems)**

A total chlorine residual of 0.5 to 1 mg/L is to be maintained at the raw water intake wet well as an indicator of effective larvae and zebra mussel control.

(b) **Power Generating Stations (Flow-Through Systems)**

A total chlorine residual of 0.5 to 1 mg/L is to be maintained at the water intake pipe/well as an indicator of effective larvae and zebra mussel control.

Total chlorine residual in the discharge to the receiving water course shall not exceed 0.01 mg/L.

(c) **Industry and Other Water Taking Establishments (Including No Direct Discharge Systems)**

A total chlorine residual of 0.5 mg/L to 1 mg/L is to be maintained at the raw water intake as an indicator of effective larvae and zebra mussel control.

Total chlorine residual in the discharge to a receiving water course shall not exceed 0.01 mg/L.

4.4 MONITORING AND REPORTING

4.4.1 The owner shall ensure that the following monitoring program is carried out:

(a) Samples of chlorinated raw water and treated water shall be collected and analyzed for at least the following parameters at the indicated sampling locations and sampling frequency:

Sampling Location - Chlorinated Raw Water (All Systems)

Parameter	Frequency
Total chlorine residual	continuous
	(Water Treatment Plants)
Turbidity	daily

Sampling Location - **Treated Water (Water Treatment Plants)**

Parameter	Frequency
Total chlorine residual	continuous
Trihalomethanes	(See NOTE below)

NOTE: Where there is insufficient current data on Trihalomethanes, an intensive sampling program should be initiated during the chlorine addition period. An initial sample must be taken at the start of the chlorine addition period followed by bi-weekly sampling with the option of extending the frequency to monthly or bi-monthly - once the data base on THMS has been established. The sampling program and frequency requirements should be co-ordinated with the Ministry's District Office/Drinking Water Section, Water Resources Branch.

Sampling Location - **Discharge Water (Flow-Through Systems/Industry)**

Parameter	Frequency
Total chlorine residual	continuous

(b) **Biological Study - Flow-Through Systems and Direct Dischargers**

A biological program to monitor the impact of chlorination on benthic organisms in the discharge plume shall be initiated within two weeks prior to start-up of chlorine addition and within two weeks after completion of chlorine addition, and is to include:

- a minimum of six sampling sites - three within the plume and three (reference sites) outside the plume;
- sampling techniques:
  - three benthic samples at each site,
  - sample to be at least 0.05 m^2 in area, and
  - the maximum mesh size less than 0.6 mm;
- taxonomical analyses of macro invertebrates will be to the lowest practical levels, i.e. generic level for insects and clams, and specific level for mature worms, leeches, crustaceans, snails and mussels;

- multivariate analyses shall be used to contrast sampling sites within the plume to those outside the plume for each time period.

(c) The owner shall submit the analytical results obtained pursuant to sub-section (a) to the District Office within thirty (30) days of collection of the samples or within such longer period of time as the District Office may agree.

(d) If the owner monitors any of the parameters required by subsections (a) and (b) more frequently than is required, the analytical results of all such samples shall be included in the reporting.

4.4.2 The owner shall prepare and submit an annual performance report to the Regional Director within thirty (30) days of the completion of the calendar year being reported upon, or as agreed to by the District Officer, or as stipulated below. The report shall contain, but need not be limited to, the following information in a format acceptable to the District Officer:

(a) a summary of the quantity of chlorine used with special reference to any abnormal usages, and discussion of effectiveness on zebra mussel control;

(b) a summary and interpretation of the analytical results; and

(c) for all flow-through systems and direct dischargers, the requirements are:

- availability of a "Taxa List" to the District Officer at his request, within 30 days of benthic sampling;

- a report within 90 days after completion of chlorine addition;

- a summary and update of alternative control measures being evaluated or proposed for evaluation at the site.

5.0 REASONS FOR IMPOSITION OF CONDITIONS

Condition 4.1 is included to define one of the term(s) used in the Certificate of Approval.

Condition 4.2 is included to ensure that the works are operated satisfactorily.

Condition 4.3 is included to ensure that the addition of chlorine in controlled amounts will not result in the following:

- adverse impacts on benthic organisms downstream of discharges from flow-through systems, i.e. variation between reference and plume sites after the period of control, shall not differ significantly from the variation before the treatment period.

Condition 4.4 is included to ensure that the sampling and monitoring program data are available for assessing the effectiveness of the use of chlorine, as a short-term control measure, on zebra mussel infestations of water taking facilities, and for reporting on other potential control measures.

6.0 DRAFT COVERING LETTER

RE: Name of Applicant
Description of Works
MOE File No.

Enclosed herewith is the Ministry's Certificate of Approval No. _____, dated _____, covering the _____ (description of works) _____.

In providing the attached certificate, the following should be noted:

1. Chemical Addition

   The use of chlorine (*chlorine gas/sodium hypochlorite) is considered as an interim means of offsetting the build-up of zebra mussels in water intake pipes. Its use is contingent on:

   *(a) having undertaking a zebra mussel monitoring program in the immediate area/confirmation of the presence of zebra mussels in adjacent intake waters;

   *(b) chemical addition only when the water temperature is approximately 12°C or when zebra mussel veliger larvae are present.

2. If it is necessary to modify your works to comply with other alternative longer term solutions to the problem or other comprehensive regulations, you will be required to apply for the appropriate approvals at that time.

Copies of this advisory letter and the attached Certificate of Approval are being forwarded to the persons indicated.

Yours very truly,

_____
Manager
*Municipal/Industrial Approvals
Section

cc: Director, Approvals Branch
Regional Directors
District Officers
Consultant, etc.

* Delete as applicable.

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